Brain maps and plasticity molecules
Part 2: the NMDA receptor

What you need to know from this lecture:

1. Structure of the NMDA receptor
2. Function of the NMDA receptor – how it works as a coincidence detector
3. Cooperation between AMPA and NMDA receptors in activity-dependent plasticity

Plasticity

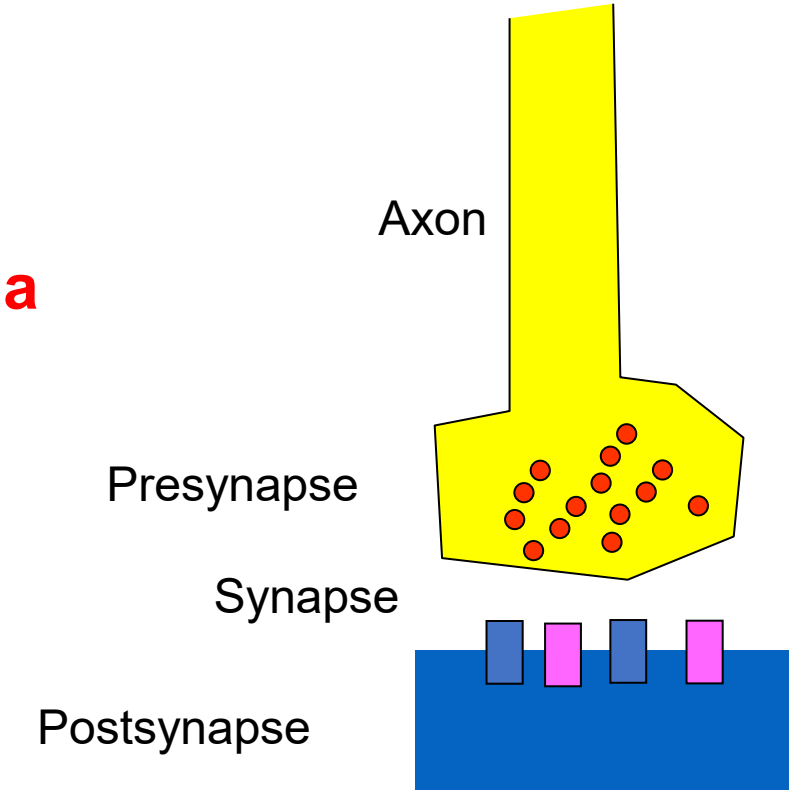
Makes certain neural circuits more efficient

Underlies adaptation, learning and memory

Every time you learn something, neural circuits are altered in your brain.

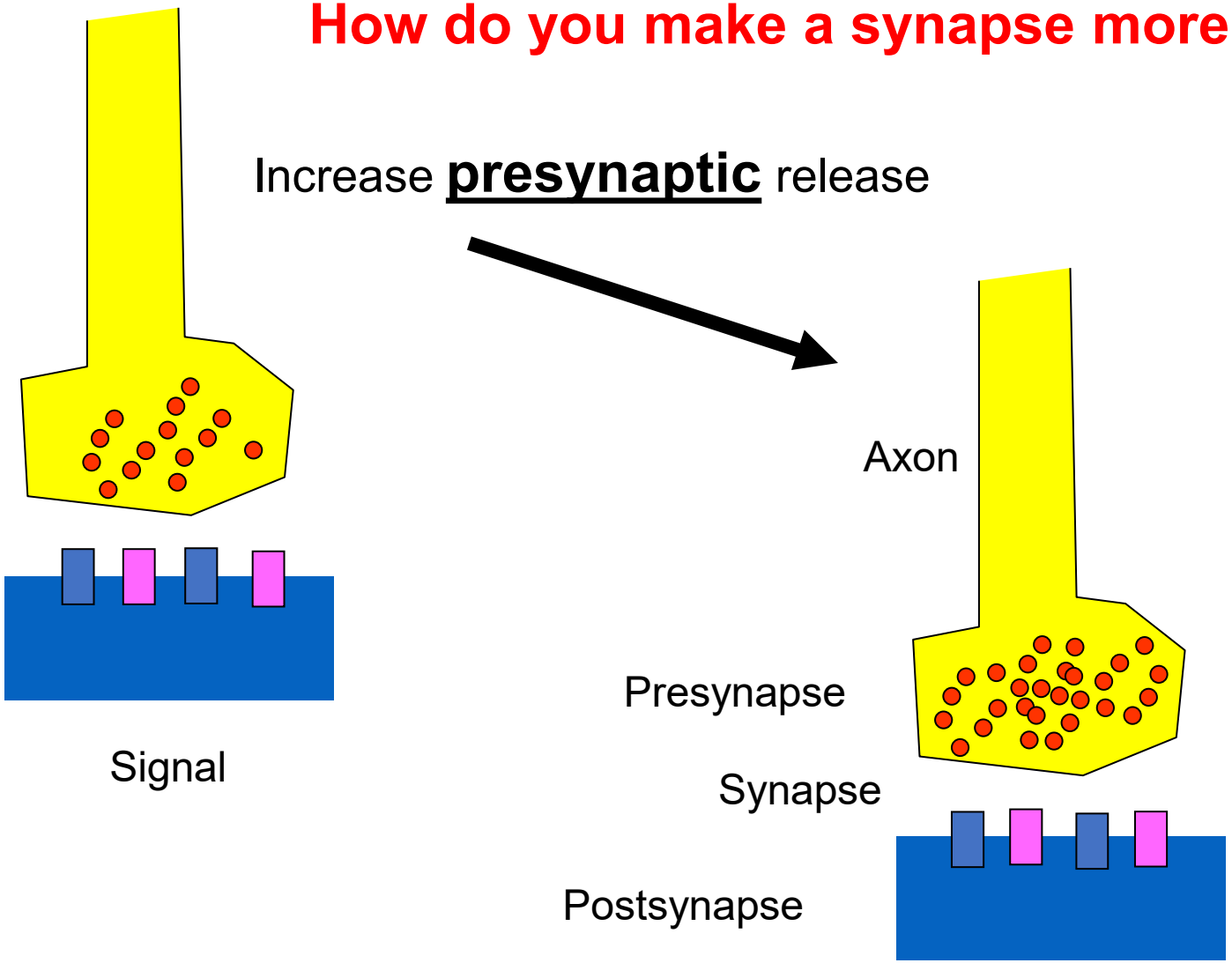
Synapse efficiency increases, thus facilitating the passage of nerve impulses along a particular circuit.

How do you make a synapse more efficient?



How do you make a synapse more efficient?

Increase **presynaptic** release

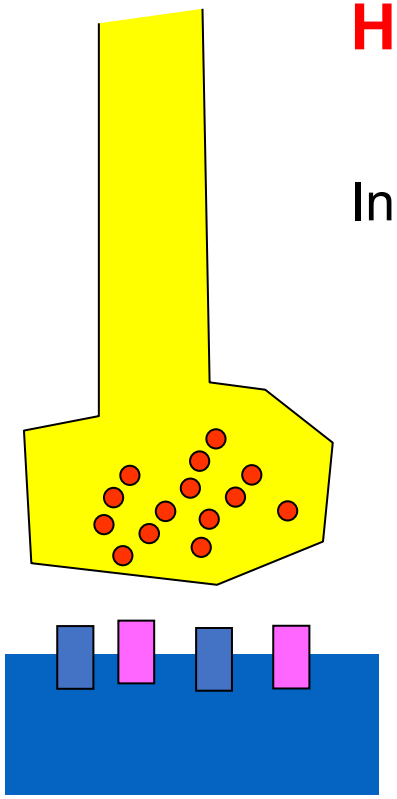


Long term potentiation (LTP)

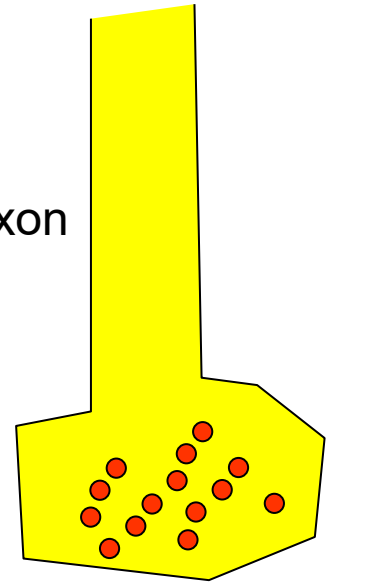
Signal!!!!

How do you make a synapse more efficient?

Increase **postsynaptic** detection



Signal

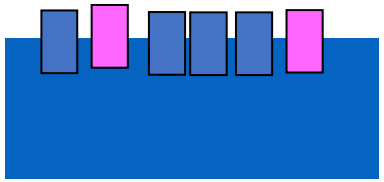


Axon

Presynapse

Synapse

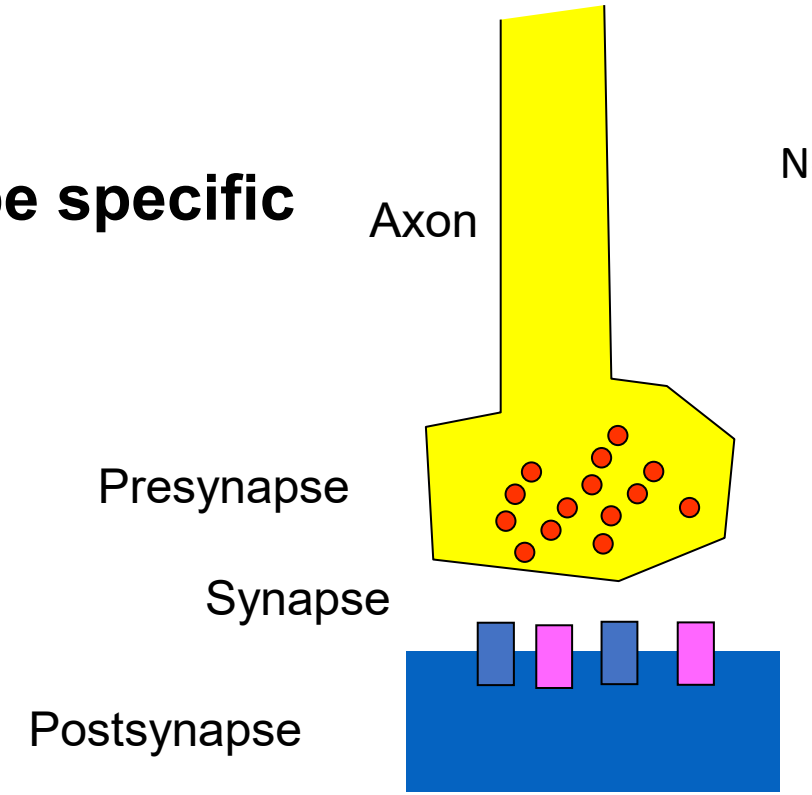
Postsynapse



Signal!!!!

Long term potentiation (LTP)

Lets be specific



Neurotransmitter: glutamate

Neurotransmitter receptors:
AMPA receptor
NMDA receptor

Neural circuits can become more efficient
(increase pre- or postsynaptic component)

Q. – How does the brain decide which ones should be more efficient? (trigger)

A molecular coincidence detector:
The N-methyl D-aspartate (NMDA) receptor

- **Protein: sits in the membrane of neurons**
- **Ion channel: lets ions in and out of the cell**

A molecular coincidence detector:
The N-methyl D-aspartate (NMDA) receptor

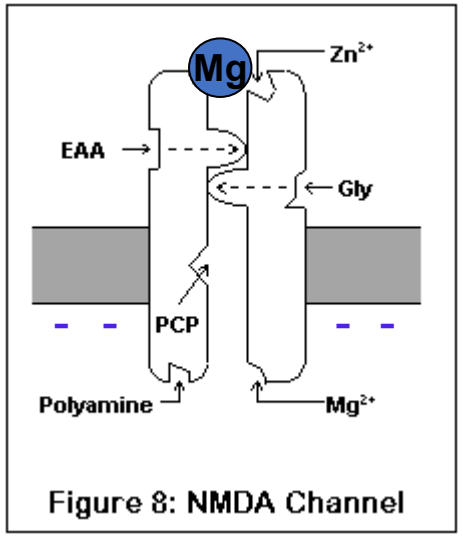


Figure 8: NMDA Channel

Glutamate binds

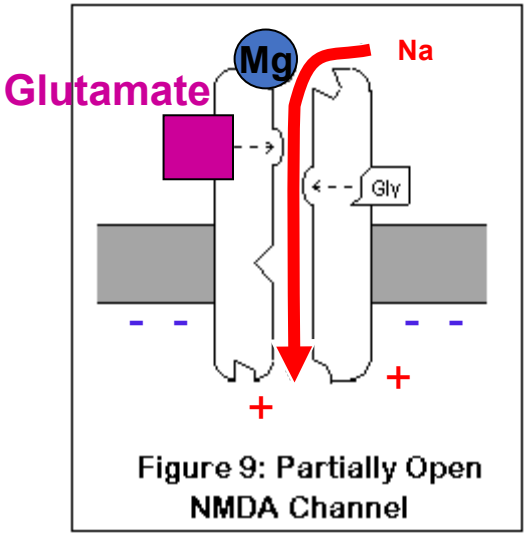


Figure 9: Partially Open NMDA Channel

Na influx:
Change in current
Short term

Glutamate binds again

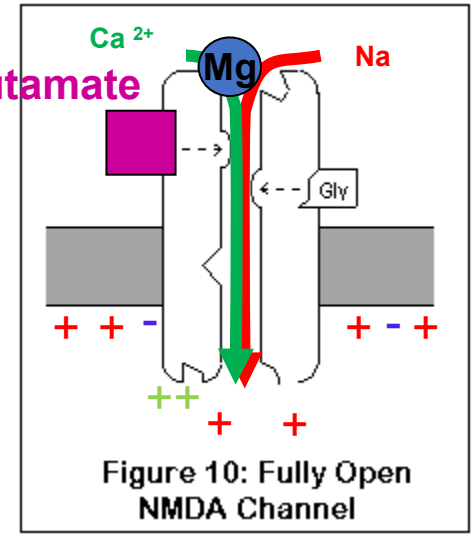


Figure 10: Fully Open NMDA Channel

Na and Ca influx:
Change in current
Change in gene expression
Long term

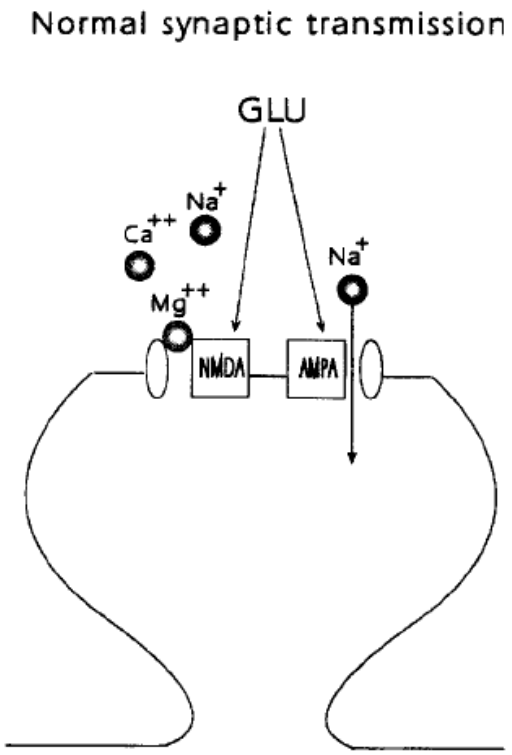
NMDA receptor is double-gated

- **Ligand-dependent (glutamate)**

- **Voltage-dependent (depolarization removes magnesium from the channel pore)**

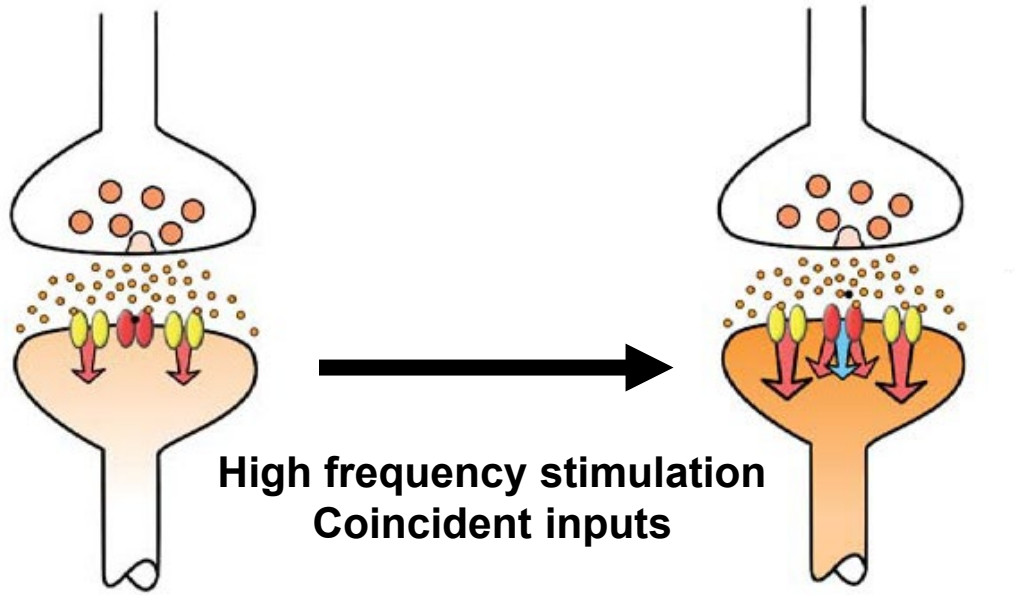
NMDA receptor gating detects the coincidence of two incoming signals

AMPA receptors: baseline reliable synaptic transmission
NMDA receptors: coicidence detection, triggers for plasticity

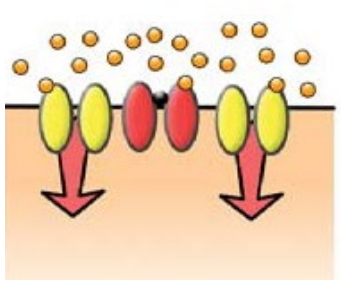


postsynaptic spine

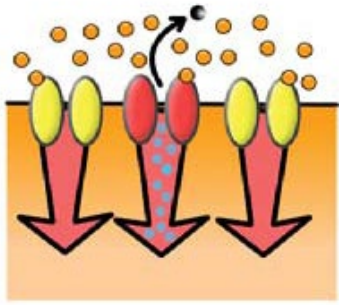
Baseline transmission Plasticity



High frequency stimulation
Coincident inputs



Na influx:
Transmission of action potential
(AMPA receptors: yellow)



Ca influx (NMDA receptors: red):
Changes in synapse structure
and gene expression

Neurons that fire together wire together

An active or important brain region
will acquire more connections and become bigger

Use it or lose it

An inactive or infrequently used brain region
will lose connections and become smaller.

Active regions can take over inactive regions